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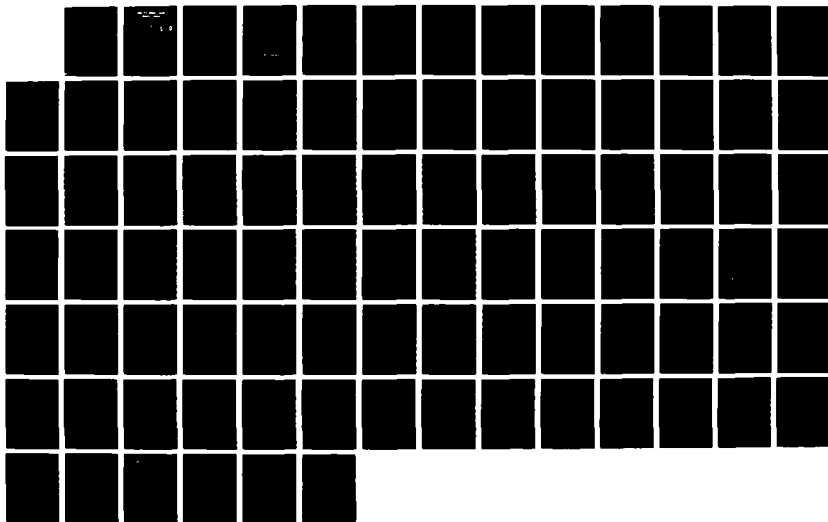
PRODUCTIVITY MEASUREMENT AND ANALYSIS OF AIRBORNE
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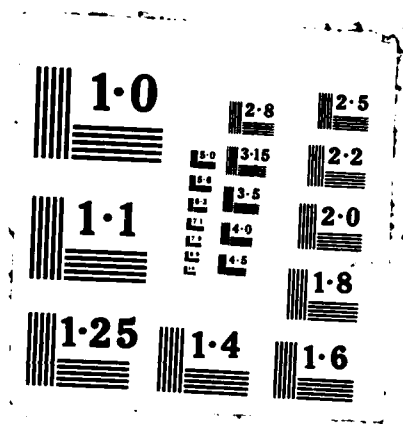
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THESIS

Productivity Measurement and Analysis
of Airborne Weapons Maintenance Plans
Performed by the Weapons Support Directorate,
Pacific Missile Test Center, Pt. Mugu

by

Jacqueline L. Knudson

December 1987

Thesis Advisor:

David R. Whipple

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Productivity Measurement and Analysis
of Airborne Weapons Maintenance Plans
Performed by the Weapons Support Directorate,
Pacific Missile Test Center, Pt. Mugu

by

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B. S., University of Washington, 1983


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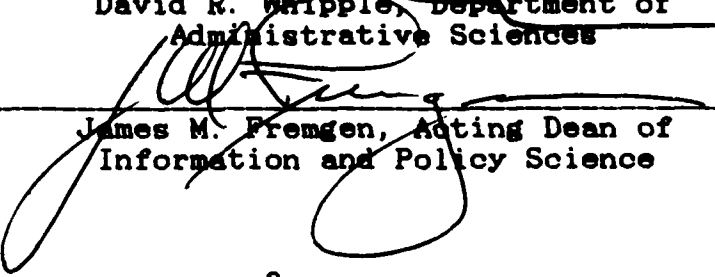

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ABSTRACT

The President's Productivity Improvement Program for the Federal Government, Executive Order 12552 of February 25, 1986, places a requirement that DOD show a 20% increase in productivity over a five year period, ending in 1992. Productivity is difficult to measure, especially when trying to measure the productivity of a service. This thesis develops a measure of productivity for one specific service. The service measured is revising Airborne Weapons Maintenance Plans performed by the Weapons Support Directorate, Pacific Missile Test Center, Pt. Mugu, California.

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I. INTRODUCTION

A. BACKGROUND

1. Background of the Policies Concerning Productivity in the Federal Government and the Department of Defense

The Department of Defense (DOD) is asked to provide more defense for the budget dollar year after year. The only way to accomplish this is to increase DOD's productivity.

Current emphasis on productivity originated with the President's Productivity Improvement Program for the Federal Government, Executive Order 12552 of February 25, 1986. The specific goal of this program is "to improve the quality and timeliness of service to the public, and to achieve a 20 percent productivity increase in appropriate functions by 1992." [Ref. 1:pp. 7041] The Office of Management and Budget (OMB) was given overall direction of the program.

The OMB issued Bulletin 86-6 of February 28, 1986 [Ref. 2] (since superseded by OMB Bulletin 87-12 of May 14, 1987 [Ref. 3]) to provide guidelines for the development and implementation of agency productivity programs. These bulletins established the requirement for agency Productivity Plans. Initially, this program is to apply to 20 executive agencies, the Department of Defense included.

Applications to all other agencies is expected to occur in the future. Bulletin 86-6 defined the roles of the Office of Personnel Management (OPM) and the Bureau of Labor and Statistics (BLS). The OPM is to:

- review and recommend revision to personnel policy.
 - develop and implement programs for federal employees on measurement, quality and productivity management.
 - assist agencies in their job placement and retraining efforts to minimize negative impacts on employees.
 - develop and issue materials to assist agencies in carrying out flexible personnel practices.
- [Ref. 3:pp. 7]

The BLS is to provide "technical assistance to OMB and executive agencies on productivity measurement."

[Ref. 3:pp. 7]

As part of the Department of Defense, the Department of the Navy prepared its Productivity Plan. This plan identified three functional areas with which to start: Aircraft Maintenance; Ships' Maintenance; and, Weapons Systems' Maintenance. The scope of the program includes all shore facilities that support these functions. [Ref. 4] Since both Naval Air Systems Command's (NAVAIRSYSCOM) and Pacific Missile Test Center, Pt. Mugu's (PACMISTESTCEN) missions involve weapon system maintenance, they to must meet the requirements of this program.

NAVAIRSYSCOM and PACMISTESTCEN both have initiated Productivity Programs. These plans are primarily strategic plans for long term productivity improvement. However, in

order to document their improvements, they will need to first establish measures for productivity. Next, a baseline for future comparison must be established. If the data exists to produce measures, Fiscal Year 1985 is to be the baseline year. If not, then the earliest fiscal year practicable must be used. [Ref. 3:pp. 5]

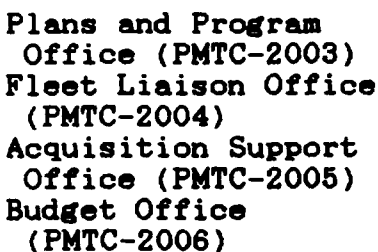
2. Organizational Structure of the Weapons Support Directorate, PACMISTESTCEN

a. Weapons Support Directorate Structure

The Weapons Support Directorate is a directorate under the Commander, Pacific Missile Test Center, Pt. Mugu. The Weapons Support Directorate is tasked to perform a variety of services. These include:

- provide Integrated Logistics Support (ILS) for the Fleet for airborne weapons.
- develop, prescribe, update and monitor the procedures for maintenance of air-launched weapons, weapons systems, support equipment and related devices.
- provide on-site technical advisors for Fleet and Shore based maintenance activities world wide.
- provide basic engineering and production engineering support of product improvement programs and procurement support for bomb systems, guns, and ammunition, suspension and release systems, and systems integration. [Ref. 5:pp. 2000-1]

The Weapons Support Directorate consists of five functional divisions and five supporting offices (Figure 1).



b. The Weapons Support Directorate's Relationship to NAVAIRSYSCOM

(1) Services Performed for NAVAIRSYSCOM. The Weapons Support Directorate provides the following services specifically for NAVAIRSYSCOM:

- basic design engineering and production support on assigned armament launcher propulsion systems for NAVAIRSYSCOM-540.
- functional engineering support to NAVAIRSYSCOM-552 for Armament Support Equipment.
- Air-Launched Weapons Shipboard and handling installation for NAVAIRSYSCOM-511.
- logistics and engineering evaluations in support of the Airborne Weapons Logistics division of NAVAIRSYSCOM-418.

(2) The Weapons Support Directorate's Relationship to NAVAIRSYSCOM-418. NAVAIRSYSCOM-418 is a major consumer of the services provided by the Weapons Support Directorate. NAVAIRSYSCOM-418 is responsible for in-service* logistics support for all air-launched weapons in the Navy. NAVAIRSYSCOM-418 will evaluate the need for a specific service (e.g. a logistics impact evaluation of an engineering change proposal). If they determine that the

*In-service refers to any stage in the life cycle of the weapon system after it enters into production.

work is needed, they may:

- do the work themselves.
- issue a commercial contract to have the work done.
- issue a work unit assignment to a specific field activity, such as PACMISTESTCEN, to have the work done.

This is how the Weapons Support Directorate receives a majority of its workload, including Airborne Weapons Maintenance Plan revisions.

B. RESEARCH OBJECTIVES AND METHODOLOGY

1. Research Objectives

The goal of this research is to provide a way to measure the productivity of services performed by the Weapons Support Directorate, PACMISTESTCEN. Recent initiatives within the federal government have led to the requirement that the Weapons Support Directorate show a 20% increase in productivity over a five year period ending in 1992. Therefore, the need for productivity measurement within the Weapons Support Directorate is created. The objectives of this thesis are to:

- a. Apply an existing method to measure the productivity of a single group of services performed by the Weapons Support Directorate, PACMISTESTCEN. The group of services chosen was the revision of Airborne Weapons Maintenance Plans. The approach used is the one presented by Marvin E. Mundel in his book

Measuring and Enhancing Productivity of Service and Government Organizations [Ref. 6].

- b. Evaluate ways to enhance the productivity of the organization with respect to the specific service of revising the Airborne Weapons Maintenance Plans for NAVAIRSYSCOM-418, discovered in the course of researching the objective a.

2. Scope, Limitations, and Assumptions

- a. Scope

Revisions of Airborne Weapons Maintenance Plans was chosen because development a productivity measurement model for all of the services performed by the Weapons Support Directorate is considered to be too broad in scope. However, it is desired that the method used be applicable to the entire Weapons Support Directorate. There are two basic reasons that this particular task was chosen:

- this task is similar enough in nature to other logistics and engineering services performed by the Weapons Support Directorate. Therefore, the general approach used should be applicable to those services as well.
- not all Airborne Weapons Maintenance plans are contracted out like some other services performed by the Weapons Support Directorate. Therefore, improvement in the productivity of the government work

will result in a reduction in the total cost of this service.

b. Limitations

No limitations were encountered.

c. Assumptions

Assumptions made were that the organization would remain stable and that the policies concerning productivity measurement would remain constant.

3. Methodology

The primary methodology used to collect data for this study was archival research. A literature review was performed to develop a theoretical background in the study of productivity measurement and improvement in the service sector and to search for an existing model or approach to apply to this case. The implementation of the President's Productivity Improvement Program for the Federal Government was traced through OMB, DOD, the Navy, NAVAIRSYSCOM to the Weapons Support Directorate of PACMISTESTCEN. This documentation was obtained at NAVAIRSYSCOM-418, the Weapons Support Directorate or the Naval Postgraduate School Library. Interviews were used to gain additional information on NAVAIRSYSCOM and PACMISTESTCEN policies on productivity measurement and improvement.

Research was conducted into the procedures used to revise Airborne Weapons Maintenance Plans at the Weapons Support Directorate and at NAVAIRSYSCOM-418. This

documentation originated from NAVAIRSYSCOM-418 and the Weapons Support Directorate, PACMISTESTCEN. Interviews with employees involved in the preparation of these Maintenance Plans were used to collect general workload data, clarify procedures and documentation used to prepare revised Maintenance Plans. Finally, these personnel were asked to provide their ideas on productivity and quality enhancements.

C. ORGANIZATION OF STUDY AND SUMMARY OF FINDING

1. Organization

Chapter Two is the literature review and theoretical framework of productivity productivity measurement. General approaches to productivity measure development are reviewed. Chapter Three presents the methodology of the research and the data collected. A procedure to measure productivity developed by Marvin E. Mundel [Ref. 6] is presented. Chapter Four shows how the procedure developed by Mundel can be adapted for revising Airborne Weapons Maintenance Plans to develop a standard time for Airborne Weapons Maintenance Plan revisions and a productivity index. Suggested ways to enhance the productivity of this service are evaluated. Finally, Chapter Five contains the summary and conclusions.

2. Summary of Findings

A productivity index can be developed for the task of revising Airborne Weapons Maintenance Plans. Further, the proposed procedure is general enough so that it can be applied to other services performed by the Weapons Support Directorate. Participative management techniques enhance the effectiveness of the measurement system when developed. Employee participation also encourages productivity and quality improvement.

II. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

A. WHAT IS PRODUCTIVITY?

1. Productivity Defined

The definition of productivity varies throughout the literature. However, there are two basic concepts which appear most often.

The first is that productivity is a function of how efficiently resources are used to produce the output of the organization. It is the ratio of outputs produced and the inputs used to produce those outputs. This definition assumes that a given level of quality, performance or effectiveness is maintained. [Refs. 3 & 6-10]

$$\text{Productivity} = f(\text{Efficiency})$$

$$= \frac{\text{Quantity of Outputs}}{\text{Quantity of Inputs}}$$

D. Scott Sink further specifies that productivity is one of seven criteria; "effectiveness, efficiency, quality, quality of worklife, innovation, cost and prices (profitability), and productivity." [Ref. 10:pp. 17], which make up organizational performance.

The second definition includes the effectiveness of the outputs produced to the above measure [Refs. 11 & 12].

$$\begin{aligned}\text{Productivity} &= f(\text{Effectiveness, Efficiency}) \\ &= \frac{\text{Quantity of Outputs}}{\text{Quantity of Inputs}} + \text{Effectiveness}\end{aligned}$$

This argument is made under the premise that an organization should not be considered productive, no matter how efficient they are, if they are producing goods and services that are not needed.

The National Center for Productivity and Quality of Worklife [Ref. 13] uses both definitions. The former is used when the program outputs can be directly related to program results (Figure 2).

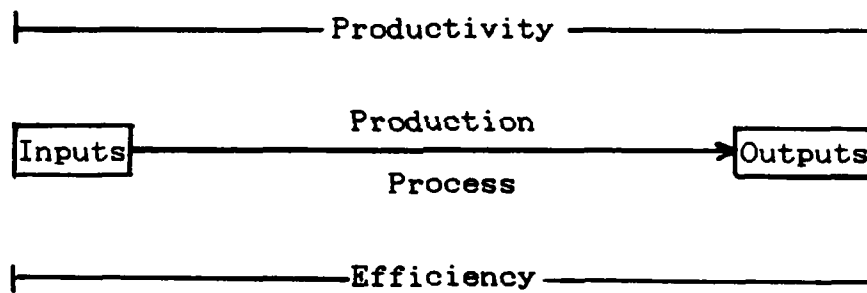


Figure 2

Direct Results Programs [Ref. 13:pp. 4]

The latter definition is used when program outputs are indirectly related to the program results (Figure 3). An example of this would be spending for the Department of Defense. Program outputs, for the most part, are

quantifiable, (e.g. number of ships manned), but the program results are not easily obtained from this measure. In other words, how much defense does a 600 ship navy produce? Often, surrogate measures of programs results are used [Refs. 10 & 13].

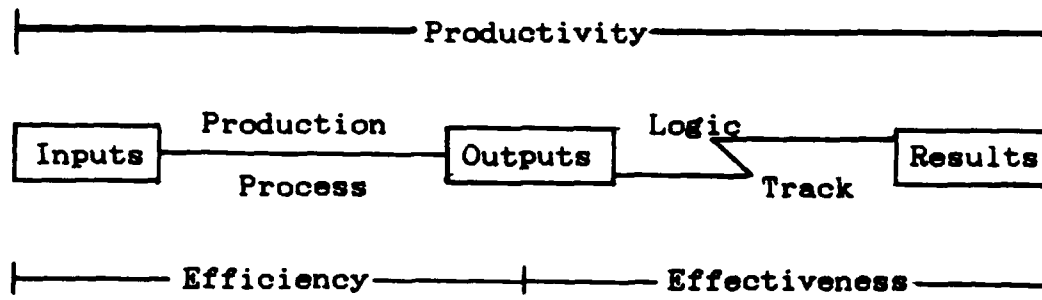


Figure 3
Indirect Program Results [Ref. 13:pp. 4]

2. Systems Concept

Productivity may be better understood as a system [Refs. 9 & 10]. Organizations use inputs to create outputs through a productive system as illustrated in Figure 4. Demand for the particular output has created a need for the productive system. Therefore, this productive system is often the justification for the organization's existence.

Inputs to the productive system include raw materials, labor, capital or any combination of these.

The productive system transforms the inputs into the final output.

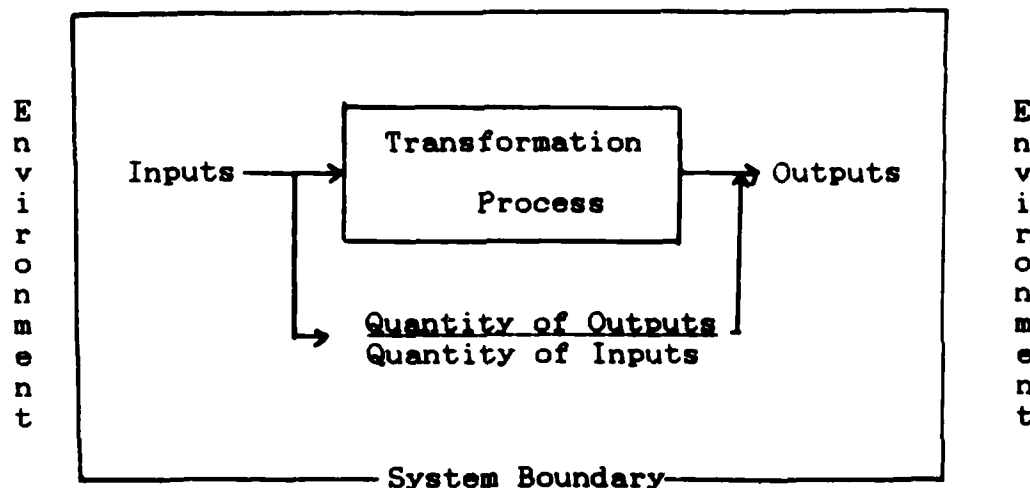


Figure 4

A Productive System, Adapted From [Ref. 10:pp. 27]

B. PRODUCTIVITY MEASUREMENT

In order to determine how efficiently and effectively resources are used within an organization a system of measurement must first be established. "Measurement is a means to an end--in this case, improvement. Measurement necessarily precedes evaluation, control, and improvement." [Ref. 10:pp. 16] From this measurement process a baseline productivity value can be developed. This baseline value is compared with current values for productivity to show changes in the organization's efficiency and effectiveness.

1. Multidisciplinary Approach

Productivity measurement is multidisciplinary.

"That is, the approach to measuring productivity is determined by the perspective of those doing the measuring." [Ref. 11:pp. 3] Productivity measurement may rely upon the following disciplines: Economics, Industrial Engineering, Accounting, Organizational Psychology, Management or Human Factors. [Refs. 6, 8, 10 & 11]

The perspective chosen may be one or a combination of the above perspectives, depending upon the characteristics of the system to be measured. Measures of productivity which are macroscopic in nature (e.g. a large firm, an industry or a nation) will tend towards the accountant's and/or economist's perspective [Ref.s 8-11]. If the system is microscopic in nature, the Industrial Engineering, Human Factors or Organizational Psychology perspectives may be more appropriate [Refs. 10 & 11].

2. Types of Measurements

D. Scott Sink categorized two basic types of productivity measures. The first type are called "static productivity ratios." This type of measure is output divided by input over a specified period of time. The second type are called "dynamic productivity indexes." This is a given static productivity ratio for some time period divided by another static productivity ratios for a

baseline time period [Ref. 10:pp. 25]. Both types of measures appear frequently in the literature.

D. Scott Sink further defined three types of productivity measures within each category described above. They are partial-factor, multi-factor and total-factor measures. These differ in the number of classes of inputs that are used in the denominator. Partial-factor is appropriate when only one class of input is used, e.g. labor or capital, in the measure. Multi-factor measures involve more than one class, and total-factor all classes, of inputs are captured in the measure. [Ref. 10: pp. 25-26] The type used will therefore depend upon the characteristics of the system to be measured.

C. WHAT SHOULD BE INCLUDED IN THE PRODUCTIVITY MEASUREMENT MEASUREMENT PROCESS?

1. What to Include?

This is a difficult question. The measurement system should include all important aspects of the organization, a common theme in the literature [Refs. 6 & 9-13]. D. Scott Sink raises the following issues in determining what should be measured:

- Which ratios and indexes will give the most insight,
- How to link productivity measurement with system control and improvement; and
- Certain outputs and attributes are difficult to quantify. [Ref. 10:pp. 31]

Failure to include key aspects of the organization can have significant consequences.

If the system is not complete, it could easily encourage neglect of those objectives not included as part of the measurement system. In such a situation, the overall effectiveness of the organization would suffer.
[Ref. 11:pp. 5]

2. People Involvement

There are two factors which heavily influence the success of implementing a productivity measurement and improvement program. They are management support for the program and employee involvement in developing the program.

a. Management Support

Upper level management support is needed to ensure success of the program. A lack of support here will fail to generate support for the program at the worker level. A productivity plan can be used in conjunction with an organization's long range strategic plan to improve performance. Productivity measurement provides a tool to measure how effectively the organization is achieving its stated objectives. It provides feedback to management on where (effectiveness) the organization is going and how efficiently it is getting there. [Refs. 10 - 12]

b. Employee Involvement

The input of key employees into the establishment of a productivity measurement system is crucial. The employee has the advantage of knowing his or her job better than anyone else. The employee will know

what changes will make him or her more (or less) productive. They are more capable of determining how a proposed system may be manipulated to show apparent productivity gains vice real ones. [Refs. 6 & 10-12]

Robert D. Pritchard, et al, found that the,

lower level of supervision know the most about the functioning of the unit, and what are the real critical issues. In addition, these are the people what will make the system work. It is important to have their involvement and knowledge from the start."
[Ref. 11:pp. 63]

An additional advantage to using an employee developed measurement system is that the employees are more committed to it. It allows "representatives of those organizational systems who are going to be affected by an issue, problem, decision or implementation a chance to influence the approach and results and build commitment." [Ref. 14] This approach is consistent with the policy stated in OMB Bulletin 87-12, "employee involvement is a process that provides employees with the opportunity to participate in the decisions that affect their work and work environment." [Ref. 3:pp. 3]

D. PRODUCTIVITY MEASUREMENT METHOD REVIEW

Three methods for measuring productivity that are applicable to the Airborne Weapons Maintenance Plan will be reviewed.

1. Normative Productivity Measurement Methodology

The Normative Productivity Measurement Methodology is a productivity measurement technique developed by the Ohio State University Productivity Research Group (1975-1978) [Ref. 10:pp. 94]. This method is applicable at the department and work group levels [Ref. 10:pp. 89]. The stages of the methodology are as follows:

- Stage 1 - Nominal Group Technique or Delphi Technique*
The Nominal Group Technique or Delphi Techniques are used to create a prioritized list of of measurement for each specified unit of analysis. Outputs are listed as productivity measures (surrogate), ratios or indexes.
- Stage 2 - Productivity Analyst Intervention
Intervention from a productivity analyst is used to convert the prioritized measures arrived at in stage 1 to workable, functioning productivity measurement system.
- Stage 3 - Review and Refinement
This requires "briefing, review, discussion, potential revision and eventual approval," [Ref. 10:pp. 118] of the draft productivity measurement system from stage 2. An additional goal of this stage is to maintain commitment to accept the final productivity measures.

*Nominal Group Technique and Delphi Technique are highly structured group decision processes.

- Stage 4 - Integration and Implementation

This is when the productivity measurement system is integrated into the organization's performance and/or control system. Management and the Productivity

Analyst:

- (1) look for overlap or redundancy;
 - (2) link the productivity measurement system to management by objective, performance appraisal, merit evaluation and incentive type systems;
 - (3) ensure that at least informal steps being taken to begin to make this system and internal part of the way the organization does business.
- [Ref. 10:pp. 118-119]

Data is collected, analyzed, interpreted and then fed back to adjust the system.

- Stage 5 - Monitor and Feedback

At this stage, the system is operationalized. Results should be evaluated and posted.

This measurement system, if used properly can develop good measures for productivity. However, it does have one drawback in that the process takes a great deal of time; two to five years in normal [Ref. 10:pp. 112].

2. Organizational Productivity Measurement

Robert D. Pritchard, et. al., [Ref. 11] developed a four step approach to developing a productivity measurement system. His approach:

stems from the theory of organizational behavior presented by Naylor, Pritchard, and Ilgen (1980). In this theory, an individual's role is seen as a series of relationships, called 'contingencies'. These contingencies not only indicates what the important things are that the person must do in the job (called

products), but also show the relationship between the amount of each of these activities and how that level of the product is evaluated. [Ref. 11:pp. 11]

The approach is as follows:

- Step 1 - Identify Products

This is the set of objectives that the organization is expected to accomplish.

- Step 2 - Develop Indicator

This is a measure of how well the organization is generating the products in question. They should come from people in the organization.

- Step 3 - Establish Contingencies

"A contingency is the relationship between the amount of the indicator and the effectiveness of that amount of the indicator." [Ref. 11:pp. 14] (Figure 5).

The percentages on the horizontal axis reflect the maximum likely to occur and the best percentage possible of the indicator measure. These figures should be determined by personnel within the organization, usually through consensus.

- Step 4 - Put the System Together.

Once the contingencies are approved by management for each indicator, the system is put together. Data is collected for each indicator. Once the indicators are measured, the effectiveness of that level of the indicator can be determined using the contingency. These effectiveness scores are then added up to

determine the organization's overall effectiveness for that time period.

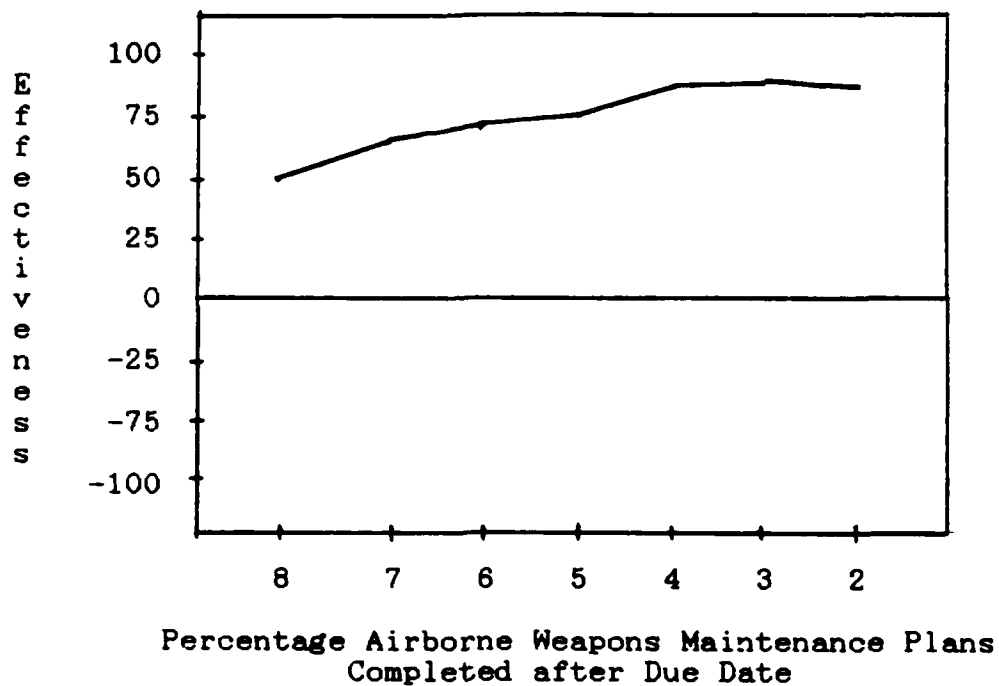


Figure 5
Example Contingency

This approach to productivity measurement has several advantages. An overall productivity score is relatively easy to attain by this method compared with other measurement systems. Productivity improvement can be directed at areas that derive the most benefit by looking at the slope of the contingency curve. The steeper the

slope, the higher the return in a productivity gain for improvement in the indicator.

This approach does have disadvantages in that it can create a large amount of additional paperwork, even if the data used is available through existing systems. Changes within organization (mission or capability) could cause a significant overhaul of the system. Also, unless the system is specifically designed to, it does not include relative input variables (labor, material) or the costs of those inputs.

3. Mundel's Approach

Mundel developed a 13 step procedure that can be used for workload forecasting, budgeting and productivity measurement [Ref. 6].

1. Performing the general reconnaissance.
 2. Developing a work-unit structure.
 3. Selecting work measurement system.
 4. Making a rough, tentative design of the manpower budget and workload forecasting system.
 5. Making a rough, tentative design of the on-going manpower and workload management system.
 6. Familiarizing all who will be affected by the changes with the new approach.
 7. Applying the selected work measurement techniques.
 8. Reducing the work measurement data to work measurement standards.
 9. The final designing and pre-testing of the manpower budget and workload forecasting system.
 10. The final designing and pre-testing of the on-going manpower and workload management system.
 11. Implementing the manpower budget and workload forecasting system.
 12. Implementing the on-going manpower and workload management system.
 13. Providing follow up assistance.
- [Ref. 6:pp. 59-60]

These steps are described in detail in Appendix. Mundel also constructs an Internal Labor Productivity Index (ILPI):

$$ILPI = \frac{OMY/MPMY}{OBY/MPBY}$$

Where:

ILPI = Internal Labor Productivity Index
OMY = Outputs achieved, in the year measured
MPMY = Manpower used, in the year measured
OBY = Outputs achieved, in a base year
MPBY = Manpower used, in a base year
[Ref. 6:pp. 7]

Mundel's approach has several advantages:

- time to implement the measurement system is usually less than the Nominal Productivity Measurement Methodology and the Organizational Productivity Measurement Approach.
- this method does not dictate a management philosophy. The two above method place a strong emphasis of group processes, which may or may not be useful, depending upon the case involved.
- this is a one time procedure that requires minimal changes to reflect changes in the organization
[Ref. 6:pp. 59].

E. SUMMARY

Productivity measurement is a complex process, especially when applied to services. The measure of

effectiveness (result) for a service is difficult to quantify, and in some cases, impossible. There can be large variations even within the same service. Airborne Weapons Maintenance Plan revisions' measure of effectiveness is impossible to quantify accurately at the time the Maintenance Plan is revised. Therefore, a surrogate outcome must be used. The APML at NAVAIRSYSCOM-418 provides this measure by accepting the revised Maintenance Plan.

The type of measurement needed is dictated, in part, by OMB Bulletin 86 - 12. In order to reflect changes in productivity over time, a dynamic measure is need. The use of the partial-factor measurement is the simplest to use and is a reasonable choice in this case. The largest contributor to the cost of revising Airborne Weapons Maintenance Plans is the labor. The data and the computer system used are both owned by the government and maintained by separate organizations.

Mundel's approach was chosen for use in this study because:

- Time to implement the measure system would be significantly shorter than some of the other methods reviewed in this case;
- The Airborne Weapons Maintenance Plan revisions are performed in part by many different work groups in the Weapons Support Directorate. The Mundel approach can

incorporate this in its the work-unit structure definition;

- The Mundel approach allows a great deal of management philosophy flexibility. Many of the other approaches reviewed required group process decision making. While it is recognized that employee participation is important to have, a structured group process may not be the best way to achieve that objective for the case involved.
- The framework approach used by Mundel is well suited to updating. The part of the work-unit structure affected may be updated, without affecting the rest of the structure.

In the next chapter the method used in the research and the data obtained will be presented.

III. METHODOLOGY AND DATA

A. METHODOLOGY

The research approach addressed:

- The basic theory of productivity and productivity measurement and model or method selection;
- The government policies concerning productivity programs;
- The information needed to apply the Mundel approach, specifically, the methodology used to prepare Airborne Weapons Maintenance Plan revisions and the organizations involved in this process; and
- The collection of data concerning productivity and quality enhancements.

1. Theory of Productivity

a. General Productivity Theory

Secondary archival research was used to develop an understanding of the theory of productivity. Research was directed to the study of productivity measurement and enhancement at the micro or organizational level. A search was made for existing models or methods of productivity measurement for the service sector.

b. Model Selection

The model or method should be specifically applicable to the service of revising Airborne Weapons

Maintenance Plans, yet general enough to be applied in a like manner to the other logistics and engineering services performed by the Weapons Support Directorate. The approach selected was that of Marvin E. Mundel, described in detail later in this chapter.

2. Government Policies

Primary archival research was used to review implementation of Executive Order 12552 [Ref. 1] through the OMB, DOD, Department of the Navy, to NAVAIRSYSCOM and the Weapons Support Directorate, PACMISTESTCEN. This consisted of reviewing Executive Order 12552, OMB Bulletins 86-6 and 87-12 and Department of the Navy, NAVAIRSYSCOM and PACMISTESTCEN productivity plans. Interviews at NAVAIRSYSCOM-04 and the Weapons Support Directorate were used to discuss implementation of their respective plans.

3. The Mundel Approach

The use of this approach required an understanding of the organization and the task being measured. Archival research and interviews were used to develop an understanding of the Weapons Support Directorate's mission and its relationship to its customers. Research material consisted of command instructions and organizational data. Interview questions were used to determine the process that Maintenance Plan Work Unit Assignments are received by and to determine general management philosophies. The relationship to NAVAIRSYSCOM-418 was also discussed.

Again, archival research and interviews were used to collect data on the Methodology used to prepare Airborne Weapons Maintenance Plan revisions. Archival research consisted of reviewing procedural manuals used to prepare and review Airborne Weapons Maintenance Planning revisions and literature on the Maintenance Plan and Supply Support (MPASS) system. Interview questions were used to ensure understanding of the procedures used and to gain general (trend) workload data. Information on the implementation and use of MPASS was also discussed.

4. Productivity Improvement

This information was collected through personal interviews of individuals who prepare and/or review Airborne Weapons Maintenance Plans. Questions were asked about the existence of problems areas that impact the productivity and quality of this service. Their suggestions for solving these problems were also solicited. Specifically, desired changes to MPASS that may enhance productivity were discussed.

The information and data collected from the above process was used to apply Marvin E. Mundel's approach to measure the productivity of the service provided by the Weapons Support Directorate.

B. THE MUNDEL PROCEDURE TO MEASURE PRODUCTIVITY

Mundel's book [Ref. 6] discussed a procedure that could be used to quantify services. His procedure consists of breaking down the objectives of the organization into programs that achieve those objectives. Programs are further broken down into end products and so on. Then work measurement techniques are applied to develop standard times and an internal labor productivity index.

1. General Procedure

Mundel uses a 13 step procedure to develop a workload forecasting system [Ref. 6:pp. 59-81]. Not all of these steps are needed to gather the information to develop a productivity index. The steps that will be used are 1, 2, 3, 6 and 7 (See Appendix for definitions of all 13 Steps).

a. Step 1, Performing a General Reconnaissance.

This is when the analyst team familiarizes itself with the organization's missions, goals, structure, assets, etc.

b. Step 2, Developing the Work Unit Structure.

This is one of the more complicated steps in the process. It is the "delineation of the outputs of the organization." [Ref. 6:pp. 62] Specifically it must:

a. Provide clear visibility of the relationship between objectives and the use of resources.

b. Provide a level of work unit suitable for forecasting the amount of output needed during future periods.

c. Provide a level of work unit suitable for applying some type of work measurement." [Ref. 6:pp. 62]

His approach to the work unit structure is contained in Table 1.

c. Step 3, Select a Work Measurement Method.

Choose the specific method for relating resource man-hours to a work unit of output. The technique chosen will depend upon:

1. The nature of the work unit.
2. The length of time per work-unit.
3. The frequency of occurrence of the work-unit.
4. The direct tenuousness of the relationship between higher and lower-orders of work-units.
5. The availability of historical data (and its reliability).
6. The attitude of the working personnel.
7. The time allowed for obtaining standard times.
8. The political situation surrounding the application of measurement. [Ref. 6:pp. 91-92]

These techniques could be simple or complex mathematical computation from work count and work time data. They may also be directed by fiat, time and motions studies, etc. In general a standard time is:

$$ST = ((WT/WC) \times M) + A$$

ST = Standard Time WT = Work Time
A = Administrative Time WC = Work Count
M = Multiplier for degree of difficulty
[Ref. 6:pp. 92]

d. Step 6, Familiarizing All Who Will Be Affected by the Changes with the New Approach.

This is the step that concerns letting people in the organization know what's going on, prior to any

TABLE 1

WORK-UNIT ORDERS [Ref. 6:pp. 30]

<u>Numerical Designation</u>	<u>Name</u>	<u>Definition</u>
8th-Order Work Unit	Results	What is achieved because of the outputs of the activity.
7th-Order Work Unit	Gross Output	A large total of end-products or completed services of the working group.
6th-Order Work Unit	Program	A group of like outputs or completed services representing part of a seventh-order work unit, but which are more homogeneous sub-group.
5th-Order Work Unit	End Product	A unit of final output; the units in which a program is quantified.
4th-Order Work Unit	Intermediate Product	A part of a unit of final output; the intermediate product may become part of the final output or merely be required to make it feasible to achieve the final output.
3rd-Order Work Unit	Task	Any part of the activity associated with the performance of a unit of assignment by either an individual or a crew.
2nd-Order Work Unit	Element	The activity associated with the performance of a part of a task which is convenient to separate to facilitate the designing of the method of performing the task.
1st-Order Work Unit	Motion	The performance of a human motion. This is the smallest work unit usually encountered in the study of work. It is used to facilitate job design or dimensioning and never appears in control systems above this level.

implementation. This is where employees can be solicited for their ideas.

e. Step 7, Applying Selected Work Measurement Techniques.

This is the data gathering stage used to develop the factors that convert manpower into work units.

2. The Internal Labor Productivity Index (ILPI)

The data gathered using the above procedure can be used to calculate the Internal Labor Productivity Index (ILPI). Productivity improvement may be measured using this index. Given that the level of quality remains constant, the change in productivity will appear as a fraction of the base year used. The ILPI is specifically related to the efficient use of labor resources. The ILPI is defined by Mundel as:

$$ILPI = \frac{OMY/MPMY}{OBY/MPBY}$$

Where:

ILPI = Internal Labor Productivity Index
OMY = Outputs achieved, in the year measured
MPMY = Manpower used, in the year measured
OBY = Outputs achieved, in a base year
MPBY = Manpower used, in a base year
[Ref. 6:pp. 7]

Outputs achieved is the number of work units completed within a year. It is similar to the work count. Manpower used is labor hours or labor years used to perform these same work units in one year. It is similar to work

time. This equation will be used in Chapter Four to obtain a productivity index for revising Airborne Weapon Maintenance Plans.

C. METHODOLOGY FOR PREPARING AIRBORNE WEAPONS MAINTENANCE PLAN REVISIONS*

Airborne Weapons Maintenance Plans are key documents in the logistics support of these weapons. Early in the program life they may be the primary logistics support document [Ref. 15].

Airborne Weapons Maintenance Plans include maintenance plans for missiles (All Up Round), major sections of the missile, containers, rockets, guns, bombs, launchers and weapons support equipment (WSE). Maintenance Plans are limited to one plan per maintenance subject. A maintenance subject is the end item. Maintenance Plans for Airborne Weapons (All Up Round) may be sectionalized (Figure 5). This means that a major section of a missile can be considered an end item in addition to the All Up Round. Therefore, only one Maintenance Plan for a major section that is common to more than one missile is needed.

*Major portions of this section has been excerpted from WSD PROMEMO 15, Methodology for Preparing Maintenance Plans [Ref. 16] and Data Item Description UDI-L-21592, Maintenance Plan, Air-Launched Weapons and Armament [Ref. 17].

The Maintenance Plans consist of three major parts. Part I is the General Consideration, Part II is the Repair Capability and Part III is the Maintenance Requirements.

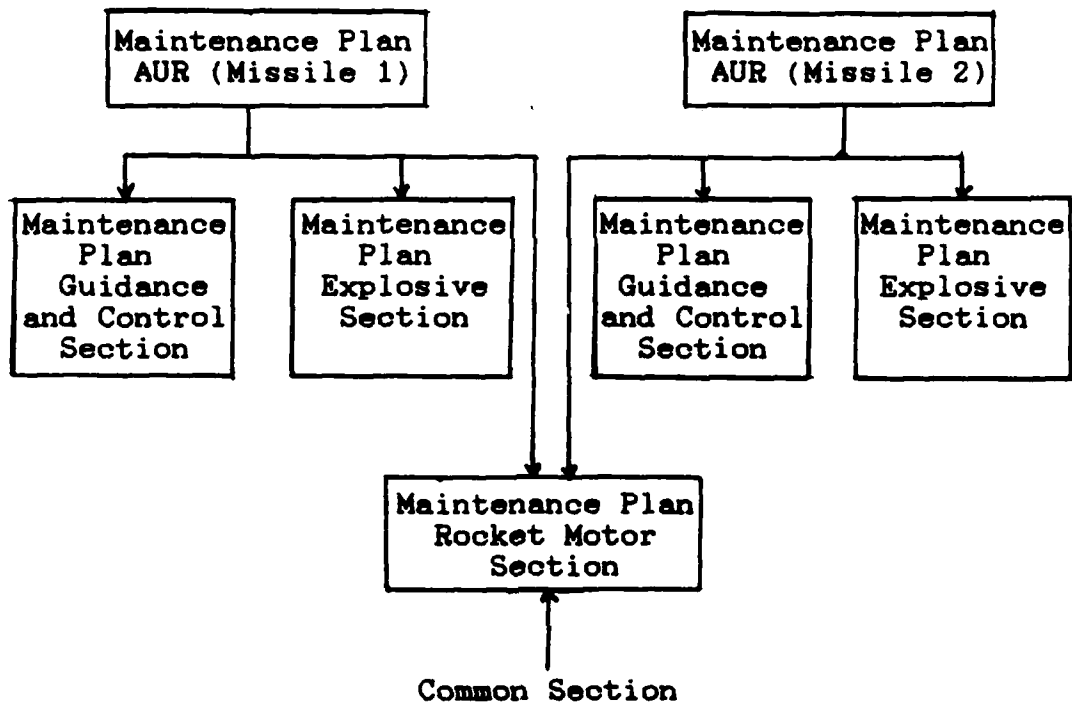


Figure 5

Example Sectionalized Maintenance Plan Structure

1. Part I-General Consideration (Figure 6)

This Part contains a Heading Information section and a Narrative section. Heading Information is a listing of certain codes and identifying information relevant to that specific plan. This same information is also

MAINTENANCE PLAN

Part I - General Considerations

1. Standing Information Name/Design _____ Application (see table I) _____ Part Number _____ NSN _____ NALC _____ SERD Number _____ DLSC Screen Data _____		Maintenance Plan No. _____ Preparing Activity _____ Prepared by _____ Reviewed by _____ Date of Submission/Rev/Date of Revision _____ / / _____ Approved by _____ Title _____		Page of Pages
2. Narrative A 2.1 DESIGN DESCRIPTION 2.2 MAINTENANCE PLAN SUMMARY 2.2.1 MAINTENANCE CONCEPT 2.2.2 ORGANIZATIONAL LEVEL MAINTENANCE 2.2.3 INTERMEDIATE LEVEL MAINTENANCE 2.2.4 DEPOT LEVEL MAINTENANCE 2.2.5 MAINTENANCE IMPACTS 2.3 PLAN RATIONALE				

Figure 6

Part I-General Consideration [Ref. 16:pp. A-6]

contained in Parts II and III. The Narrative Section contains the Design Description, the Maintenance Plan Summary and the Plan Rationale.

a. Design Description.

The Design Description is a brief functional and physical description of the maintenance plan subject. Included is a statement of how the major components function to meet the purpose of the end item. The Physical Description includes: dimension, weight, explosive load, configuration, construction and design features of repairables.

b. Maintenance Plan Summary.

The Maintenance Plan Summary contains five subsections. They are:

(1) Maintenance Concept. The Maintenance Concept is summarized from the Logistics Support Analysis (LSA) or the Integrated Logistics Support Plan (ILSP). It is an overall approach to how the missile is maintained, where, and types of maintenance to be performed.

(2) Organizational Level Maintenance (O-Level). This is a description of the types of preventive and corrective maintenance to be performed at this level, if any.

(3) Intermediate Level Maintenance (I-Level). This is a description of the types of preventive and corrective maintenance to be performed at this level, if

any. These tasks should be separated by I-Level (afloat) and I-Level (ashore). I-Level (ashore) facilities should be identified by name and location.

(4) Depot Level Maintenance (D-Level). This is a description of the corrective and preventative maintenance tasks performed at this level. The facilities should be identified by name and location.

(5) Maintenance Impacts. This section identifies areas of unusual depth and frequency of maintenance, safety constraints, unique manpower requirements, special training requirements and service time limits.

c. The Plan Rationale.

This section is used for audit/review purposes. It is the rationale used for preparation of the overall maintenance plan. The source of data used to derive the Technical Factors in Part II of the Maintenance Plan is included. Additional logistics documentation and information used is identified.

2. Part II-Repair Capability (Figure 7)

The first section of this part is the same Heading Information used in Part I. The second section is the Repairable Items/Maintenance Significant Consumables. Contained in this section is information identifying the repairables and their relationship to the system. Technical Factors are derived from the maintainability

MAINTENANCE PLAN

Part II - Repair Capability

1. Heading Information Name/Design _____ Application (see table 1) _____ Part Number _____ NSN _____ NALC _____ SERD Number _____ DLSC Summary Date _____		Maintenance Plan No. _____ Preparing Activity _____ Prepared by _____ Reviewed by _____ Date of Submission/Rev/Date of Revision _____/_____/_____ Approved by _____ Title _____										
2. Repairable Items/Maintenance Significant Components												
WUC LSACN	Part Number NSN	Manufacturer	AR QWNA	SMAR Code	Qual	Technical Factors					Page of Pages	
						CBF	MRF	RPF	DSR	RRR	NSO	
	A											

Figure 7

Part II-Repair Capability [Ref. 16:pp. A-32]

maintenance data collected at the Weapon Stations (I-Level, ashore) is used to derive the Technical Factors. This data base is call the Maintenance Data Collection System, (MDCS). These Technical Factors are used to predict provisioning and supply support requirements.

3. Part III-Maintenance Requirements (Figure 8)

Again, the first section of this part has the same Heading Information used in Part I. In the second section maintenance tasks are assigned consecutive numbers. The requirements are broken down in a top down sequence. Each requirement is a specific maintenance action. Preventive Maintenance tasks are listed first in this part. The tasks are listed sequentially by the repair level (O, I or D). They are followed by the corrective maintenance tasks, again, by level. Repair intervals and WSE needed are also listed.

D. MAINTENANCE PLAN REVIEW*

1. Review by the Weapons Support Directorate

WSD PROMEMO 18 Rev A, Maintenance Plan Review Procedures Guide [Ref. 18], establishes the requirement for the Weapons Support Directorate to review and approve all maintenance plans that they or their contractor prepares.

*This section is excerpted from WSD PROMEMO 18 Rev A, Maintenance Plan Review Procedures Guide (Ref. 18).

MAINTENANCE PLAN

Part III - Maintenance Requirements

A. Heading Information A		Maintenance Plan No. _____ Preparing Activity _____ Prepared by _____ Reviewed by _____ Date of Submission/Rev/Date of Revision _____ / ____ / ____	
Name/Design _____ Application (see table I) _____ TEC _____ Part Number _____ WUC/LBACH _____ MSN _____ FSCN _____ NALC _____ SMAR Code _____ SEED Number _____ Approved by _____ Date _____ DLSC Source Date _____ Title _____			
2. Maintenance			
Requirement Number B	Requirement C	Maintenance Level	Insured
		WSE Requirements	Page of Pages

Figure 8

Part III-Maintenance Requirements [Ref. 16:pp. A-50]

A review of the Maintenance Plan is conducted by the divisions of the Weapons Support Directorate listed in Table 2. Each branch has a specific review criteria assigned. The Maintenance Engineering Branch, PMTC Code-2021, is responsible for the overall review. These branches also make up the Review Board, when formal review is needed.

TABLE 2
AIRBORNE WEAPONS MAINTENANCE PLAN REVIEWERS

<u>PMTC Code</u>	<u>Name</u>
2021	Maintenance Engineering
2022	CLE, Air to Surface
2023	Support Equipment
2024	CLE, Air to Air
2026	CLE, Armament
2027	CLE, Advanced Systems
2034	Maintenance Production
2062	Configuration Management
2063	Data Management
CLE - Commodity Logistics Engineer	

Initially, the Maintenance Plan is routed through the appropriate PMTC codes with a Maintenance Plan Review

Sheet (Figure 9). Discrepancies and/or recommended changes are noted on this sheet. All recommended changes are returned to the Commodity Logistics Engineer or Maintenance Plan Preparer for incorporation into the Maintenance Plan. If there is a disagreement about a proposed change, a formal board meeting may be held to resolve the disagreement. An exception to this is when the Maintenance Plan was contracted by a government organization other than the Weapons Support Directorate at PACMISTESTCEN (e.g. NAVAIRSYSCOM). The board will then endorse the Maintenance Plan either recommending approval or disapproval. The distinction being that the discrepancies and recommendations are not resolved by the Weapons Support Directorate if it is not the party responsible for the contract.

2. Review by NAVAIRSYSCOM-418

Review of Maintenance Plans by NAVAIRSYSCOM-418 consists primarily of error checking. This error checking is a visual inspection for data entry errors. Certain lines of the Maintenance Plan are checked to see if they match. The Maintenance Concepts in Part I are reviewed for practicality of the approach used. The sources of data used are also reviewed. [Ref. 15]

E. MPASS

Airborne Weapons Maintenance Plans are prepared using the Maintenance Plan and Supply Support (MPASS) system.

MAINTENANCE PLAN NUMBER		TITLE	PROGRAM
REFERENCE DOCUMENTS		SUBMIT REVIEW COMMENTS TO: MP SECRETARIAT CODE: 2021 DUE DATE: MAXIMUM MANHOURS FOR REVIEW: JOB ORDER NUMBER TO BE USED: MANHOURS CHARGED (ACTUAL):	
WSD PRO MEMO 18			
ACTION CODES	REVIEW COMMENTS		
2021			
2022			
2023			
2024			
2026			
2027			
2034			
2062			
2063			
IDENTIFY SOURCE/REFERENCE MATERIALS USED TO SUBSTANTIATE COMMENTS			
RECOMMENDATION		REVIEWED BY	CODE/DATE

Figure 9

Maintenance Plan Review Sheet [Ref. 18:pp. 4]

MPASS has been on line since March 1985. Data is entered in the same format as the Maintenance Plan discussed earlier in this chapter.

MPASS is a management tool used by NAVAIRSYSCOM for the preparation/revision of Maintenance Plans. There exists a change control file associated with each Maintenance Plan within MPASS. Fleet unit and repair facility comments are entered in this file. Recently approved Engineering Change Proposals (ECPs) are also entered. The Assistant Program Manager Logistics (APML) at NAVAIRSYSCOM-418 reviews these comments periodically to determine if the Maintenance Plan is in need of formal revision. If so, he or she will prepare a Work Unit Assignment to have the revision done.

Of note is that Maintenance Plans are entered into MPASS information base as they come up for revision. In Fiscal Year 1986, 100% of the Maintenance Plans processed by PACMISTESTCEN needed to be entered into MPASS. The Fiscal Year 1987 figure is 70% [Ref. 19]. This number is expected to fall over time.

This means that a particular Maintenance Plan tasked for revision by NAVAIRSYSCOM-418 may or may not be in MPASS. If it is not in MPASS, it must be entered and then revised. This is called the 'first in the series'. Maintenance Plans that are 'first in the series' cost more to revise because of the need for a one time initial entry

into MPASS [Ref. 19]. Table 3 shows the cost differentiation and the percentages of plans received for revision that were 'first in the series'.

TABLE 3
GENERAL INFORMATION ON MPASS [Ref. 19]

Projection of Airborne Weapons Maintenance
Plan Revision Costs
(Average)

FY 1987	\$7000.00/Maintenance Plan
FY 1988, if first in series	\$6500.00/Maintenance Plan
FY 1988, if in MPASS	\$3000.00/Maintenance Plan

-First in Series means that the entire Airborne Weapons Maintenance Plan must first be entered into MPASS vice updating a previously entered Airborne Weapons Maintenance Plan.

Percent of Airborne Weapons Maintenance
Plan Work Unit Assignments that
need initial entry into MPASS

FY 1986	100%
FY 1987	70%
FY 1988	30%

F. DATA FROM INTERVIEWS

1. Individuals Interviewed

Individuals interviewed:	Dates:
Mr. Tom Eden, NAVAIRSYSCOM-04 NAVAIR-04 Productivity Representative	26 June 1987
Mr. Rob Lilly, NAVAIRSYSCOM-418 ALM Maintenance Plans	26 June 1987 12 September 1987
Mr. Lyle Hochberger, PMTC-2000 Director, Weapons Support Directorate, PACMISTESTCEN	7 August 1987
Mr. Paul Schuh, PMTC-2020 ALM Maintenance Plans	7 August 1987

2. Summaries of Interviews

Mr. Eden provided background for the productivity measurement and improvement program in effect at NAVAIRSYSCOM-04. Their Productivity Plan [Ref. 20] has seven areas in which they are focusing their improvement efforts:

1. Streamline the Acquisition process.
 2. Improve the quality of NAVAIR products, services, and processes.
 3. Improve quality of worklife.
 4. Establish and demonstrate top-level commitment and leadership.
 5. Implement participative management, including gainsharing.
 6. Improve training and education for productivity, performance and quality improvement.
 7. Improve communication with our customers.
- [Ref. 20:pp. 1]

Improvements will be measured in terms of time and/or cost saved as a result of the improvement. A formal productivity measurement system has not been implemented.

Mr. Hochberger provided his views on productivity as it impacts management of the Weapons Support Directorate. He is very interested in the development of a method to measure productivity for the entire Weapons Support Directorate. He believes that he can use productivity measurement to better manage the Weapons Support Directorate. Additionally, he needs to show the 20% improvement in productivity required by 1992. He also gave some possible constraints on the method chosen:

- attempt to limit any additional paperwork,
- use existing data collections systems where possible,
- civil service manpower levels were to remain constant.

Mr. Lilly and Mr. Schuh provided background on the importance of the Airborne Weapons Maintenance Plans in logistics support of the missiles. Both expressed concern that the Technical Factors contained in Part II of the Maintenance Plans may be inaccurate due to problems with the reliability of the data in the Maintenance Data Collection System (MDCS)*. These Technical Factors are used to determine the provisioning and supply support of the Airborne Weapons. Therefore they need to be as accurate as possible to ensure efficient supply support of

*MDCS is a computerized data base used to collect maintenance data on airborne weapons at the Weapons Station I-level repair facilities.

spare parts. Mr. Lilly would like to see a more specific explanation of the sources of this data. He believes that this would enhance the quality of the Maintenance Plan.

Mr. Schuh explained the process that an Airborne Weapons Maintenance Plan Work Unit Assignment from NAVAIRSYSCOM-418 would go through when it arrives at the Weapons Support Directorate (Figure 10). Work Unit Assignments (WUA) are either performed 'in house' by the Weapons Support Directorate or they may be contracted out. If the WUA is contracted out, it is split up into statements of work for the contract. He also provided some basic workload statistics (Table 4). He suggested the following to enhance productivity:

- Modify MPASS (Maintenance Plan and Supply Support System) to automatically compute Technical Factors from a selected data base (currently, the Technical Factors are calculated separately from the data, then entered into MPASS) and check for common data entry errors.
- Implement advance planning by having NAVAIRSYSCOM-418 give them a way to predict the Airborne Weapons Maintenance Plans expected to be assigned for revision in the near future (e.g. a one year time frame). This would be especially beneficial at the end of the fiscal year. Historically, there has been up to a

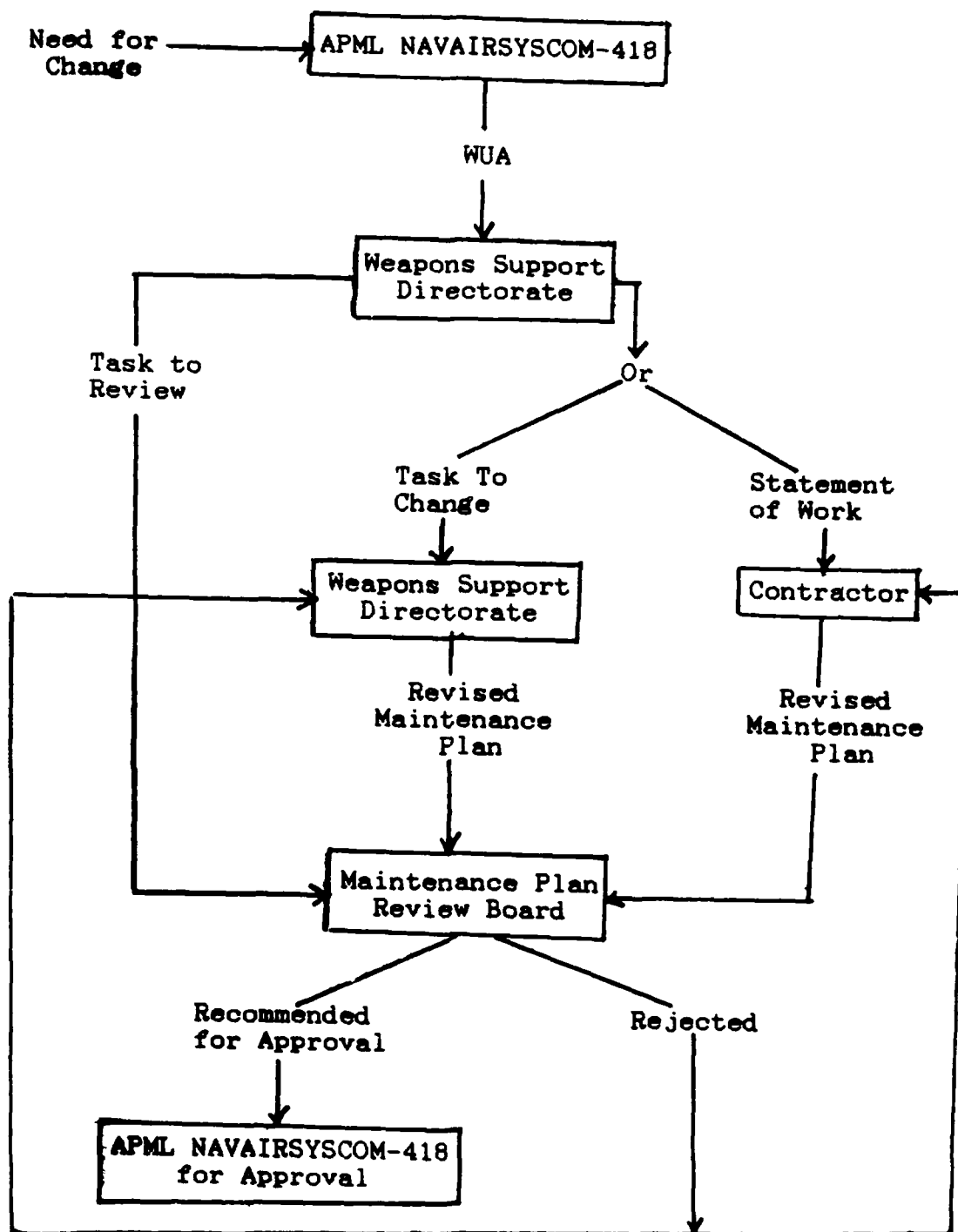


Figure 10

Flow of Airborne Weapons Maintenance Plan
Work Unit Assignments

three month lag in Work Unit Assignments assigned at this time of year.

TABLE 4
GENERAL WORKLOAD INFORMATION

Maintenance Plans currently in revision	92
Number assigned in 1986, to be completed in 1987	49
Number newly assigned in 1987	43
Number completed primarily by contract	85
Number completed by PACMISTESTCEN	7
Number of personnel working directly on Maintenance Plans	2
PACMISTESTCEN Labor Rate	\$60.64/hour
Average Contract Labor Rate	\$30.00/hour
Approximate number of contracts	4/year
Number of contractors (current)	3

G. SUMMARY

This chapter first explained the research methodology. The research was accomplished in such a way as to ensure that the service being analyzed was reasonably understood by the researcher. The organization, its customers and the methodology used to revise Airborne Weapons Maintenance Plans were all reviewed. Personnel who are involved in

revising these Maintenance Plans were consulted and encouraged to offer their ideas. This is consistent with the emphasis placed on involving personnel in the productivity measurement system development process discussed in chapter two.

The Mundel approach to measuring productivity and its application to this service were explained. The next chapter will apply this approach, using the data in sections C through F above, to develop a productivity index and a standard time model for revising Airborne Weapons Maintenance Plans.

IV. RESULTS AND ANALYSIS

This chapter is divided into two sections. The first section is an application of the procedure discussed in chapters two and three. It develops an Internal Labor Productivity Index (ILPI) for use in revising Airborne Weapons Maintenance Plans. The second section evaluates the suggestions for productivity and quality improvement obtained during the interviews.

A. THE MUNDEL APPROACH APPLIED TO THE AIRBORNE WEAPONS MAINTENANCE PLAN

1. The General Reconnaissance

The General Reconnaissance involved a review of The organizational structure of the Weapons Support Directorate at PACMISTESTCEN was reviewed and its relationship to NAVAIRSYSCOM-418. Documentation concerning Airborne Weapons Maintenance Plans was reviewed. Personnel who are involved with revising of Maintenance Plans were interviewed. Management personnel At the Weapons Support Directorate and at NAVAIRSYSCOM (Codes 04 and 418) were also interviewed.

2. Developing the Work Unit Structure

The 8th and 7th order work units (Tables 5 & 6) are gross measures of the work done at the Weapons Support Support Directorate and the Logistics Engineering Division

TABLE 5

8TH ORDER WORK UNIT--RESULT

Type of Service:

Internally consumed service to the Department of Defense.

Mission Area:

1. Provide support services for all elements of Integrated Logistics Support.
2. Et al. (List other Mission Areas, chapter one)

Purpose:

Intent:

1. To provide support services to NAVAIRSYSCOM-418's mission of in service missile logistics support.
2. Et al (intents of the other Mission Areas).

Dimension:

- 1a. Timeliness of Work Unit Assignments completed.
- 1b. Cost of Work Unit Assignment completion.
- 1c. Man-hours consumed.
- 2 Et. al. (dimensions used to measure the accomplishment of the other Mission Areas).

Freedoms:

- May prioritize the Work Unit Assignment received.
- May determine the portions of work to be contracted out.

Limitations:

- Little control of the number of work unit assignments received from NAVAIRSYSCOM-418.
- Cannot control the degree of difficulty of the work unit assignments received.
- Must work within the existing statutes pertaining to the awarding of government contracts.
- Must work within constraint of civil service manpower funding which is independent of program funding

level. They refer to the general mission areas of the Weapons Support Directorate.

TABLE 6

7TH ORDER WORK UNIT--GROSS OUTPUT

- 01 Logistics evaluation work unit assignments completed.
- 02 Design Engineering Services work unit assignments completed.
- 03 Production support services provided.
- 04 Maintenance engineering support and technical services provided.
- 05 Planning, programming and budgeting coordination for maintenance and overhaul of airborne weapons.

The 6th order work unit is the point at which the Airborne Weapons Maintenance Plans are first encountered as separate entities (Table 7). Here they are considered in total.

For the purposes of limiting the size of this thesis, only mission area one will be listed in detail for the 6th order work unit. The work unit structure used in Mundel's approach is a heirarchy. This means that for each ordered work unit listed here there are many more corresponding to it for each of the lower ordered work units. Many of these are also outside the scope of this

study. The work unit structure throughout the rest of this chapter will be listed with respect to the Airborne Weapons Maintenance Plan services only.

TABLE 7

6TH ORDER WORK UNIT--PROGRAMS

- | | |
|------|--|
| 0101 | Total Airborne Weapons Maintenance Plans completed, including review. |
| 0102 | Engineering Change Proposals evaluated logistics impacts. |
| 0103 | Transportation and handling services evaluated for logistics impacts. |
| 0104 | Storage and facilities services evaluated for logistics impacts. |
| 0105 | Personnel and training requirement services evaluated for logistics impacts. |
| 0106 | Technical documentation services. |
| 0201 | Et.al. (Other Mission Areas, see table 6) |

The 5th order work unit considers the final, approved Airborne Weapons Maintenance Plan as a single type of Maintenance Plan. For example all approved Maintenances Plans for Major Sections are counted separately from all

approved Maintenance Plans for the Weapons Support Directorate (Table 8).

TABLE 8	
5TH ORDER WORK UNIT--END PRODUCTS	
010101	Total Airborne Weapons Maintenance Plans, reviewed and approved, All Up Round.
010102	Total Airborne Weapons Maintenance Plans, reviewed and approved, Each Major Section.
010103	Total Airborne Weapons Maintenance Plans, reviewed and approved, Container.
010104	Total Airborne Weapons Maintenance Plans, reviewed and approved, Weapons Support Equipment.
010105	Et. al. (Total for other types of Airborne Weapons Maintenance Plans, e.g. bomb, armament, etc.)

The 4th order work unit (Table 9) separates the review process from the Maintenance Plan itself. They can then be monitored as separate functions. This may aid the Weapons Support Directorate in identifying initial areas to begin productivity improvement.

For example, do Maintenance Plans submitted for review have many discrepancies? If so, this will show

itself in the amount of time the plans take for review.
Therefore submitting a more accurate Maintenance Plan in

TABLE 9

4TH ORDER WORK UNIT--INTERMEDIATE PRODUCTS

01010101	Total number of reviews of Airborne Weapons Maintenance Plans, All up Round.
01010102	Total number of discrepancies corrected or recommended changes made as a result of review of Airborne Weapons Maintenance Plans, All Up Round.
01010103	Total number of Airborne Weapons Maintenance Plans completed and ready for review, All Up Round.
01010201	Total number of reviews of Airborne Weapons Maintenance Plans, Each Major Section.
01010202	Total number of discrepancies corrected or recommended changes made as a result of review of Airborne Weapons Maintenance Plans, Each Major Section.
01010203	Total number of Airborne Weapons Maintenance Plans completed and ready for review, Each Major Section.
01010301	Et. al. (Same for the other Maintenance Plan types.)

the first place may enhance overall productivity. In contrast, what if the review process is taking an

inordinate amount of time, without discovering a corresponding number of errors in the Maintenance Plan. This would mean that the review process should be scrutinized.

The 3rd order work unit (Table 10) further breaks down the intermediate products into tasks that need to be performed. They are reviewed by each division in the review process. Corrections and minor changes needed after review are done by the division responsible. Finally, the revisions of each specific Part of the Maintenance Plan are counted. Each is required to accomplish the intermediate products in the 4th order work unit.

The 2nd and 1st order work units are not shown. The 2nd order work units are the individual tasks that make up the 3rd order work unit. The 1st order work units are the motions used to complete the tasks in the 2nd order work unit. These levels of work units are difficult to measure and the measures may not provide any real insight into the productivity measurement of revising Airborne Weapons Maintenance Plans because they oversimplify the process. They also provide more detail than is necessary to create a productivity index for revising the Airborne Weapon Maintenance Plan.

Consideration should be given to employee involvement in this process. The work unit structure determines how the work is counted. As discussed earlier,

TABLE 10

3RD ORDER WORK UNIT--TASKS

0101010101	Airborne Weapons Maintenance Plans Plans, All Up Round, reviewed by PMTC-2021, Maintenance Engineering.
0101010102	Et. al. (Airborne Weapons Maintenance Plans, All Up Round reviewed by individual divisions.) . .
0101010201	Discrepancies corrected and recommended changes made by PMTC-2022, Commodity Logistics Engineer, Air to Surface, for Airborne Weapons Maintenance Plans, All Up Round.
0101010202	Et. al. (Discrepancies corrected and recommended changes made by a Maintenance Plan preparer for Airborne Weapons Maintenance Plans, All Up Round.) . .
0101010301	Completion of Part I of an Airborne Weapons Maintenance Plan, All Up Round.
0101010302	Et. al. (Completion of remaining Parts of an Airborne Weapons Maintenance Plan, All Up Round.) . .
0101020101	Same as above, except for Airborne Weapons Maintenance Plans, Each Major Section. . .
0101030101	Et. al. (Remaining Maintenance Plan types.) . .

employee input can result in a system that works well. It will also gain employee support for using the system.

3. Select a Work Measurement Method

Now that the Work Unit Structure has been developed, a work measurement technique must be identified. More specifically, the following simple mathematical computation is proposed, based upon work hours and the 4th order work units:

$$\text{Standard Time} = (\text{THi}/\text{TWCi}) \times \text{Md} \times \text{Mc}) + \text{A}$$

THi = Total hours in a specified time period worked on that particular 4th order work unit

TWCi = Total 4th order work units completed in the same specified time period.

Md = A difficulty multiplier for the specific type of Maintenance Plan being revised (e.g. a Guidance and Control Section).

Mc = A difficulty multiplier for the complexity or amount of work of the required revision (some revisions require more work than others). This multiplier should be a scale relative to overall average for that particular 4th order work unit

A = Administrative (including personal) time.

This standard time model can be used to evaluate the efficiency of the labor hours used to revise the Airborne Weapons Maintenance Plans. The labor hours used can be compared with the labor hours expected to be used given by the standard time.

This model is a good measure because it considers variations in the difficulty of revising Airborne Weapons Maintenance Plans. Two multipliers were chosen to reflect the two major causes of variation in the difficulty of revising the Airborne Weapons Maintenance Plans. M_d is a difficulty multiplier that is associated with the specific type of Maintenance Plan being revised. For example, a guidance and control section Maintenance Plan would be more difficult to revise than a container Maintenance Plan because the equipment involved is more complex. M_c is a difficulty multiplier related to the degree or variance of work inherent in the Maintenance Plan itself. Some plans may require minor revisions, while others require a comprehensive review.

Historical data needed for these computations may be available from the Job Control Numbers associated with that particular Work Unit Assignment. If this data is no longer available in the detail needed, is considered unreliable or incomplete, data collection may begin with the work currently in progress. Hours used in the review process can be logged directly on the Maintenance Plan Review Sheet, Figure 9.

4. Familiarizing All Who will be Affected by the Changes with the New Approach

This step will be fairly simple in this case. A meeting should be held to explain this approach to the

Airborne Weapons Maintenance Plan Preparers and Reviewers. These individuals should also set the multipliers used in the above standard time. These same people should also periodically review the standard time to reflect improvements made.

5. Applying Selected Work Measurement Technique

This step involves the data collection, either from historical sources or from work in progress. If work in progress is used, data should be collected over a six month period to obtain a sample large enough to give reliable estimates for the standard time model parameters.

6. The Internal Labor Productivity Index

The Internal Labor Productivity Index may be calculated as discussed in Chapter Two. First, a baseline time period must be established. OMB Bulletin 87-12 [Ref. 3] suggests that Fiscal Year 1985 be used. If insufficient data exists to establish Fiscal Year 1985 as a baseline, subsequent data collected may be used to obtain a baseline figure. The Internal Labor Productivity Index (ILPI) for revising Airborne Weapons Maintenance Plans, using a Fiscal Year 1985 baseline would be:

$$ILPI = \frac{\text{Work Unit}(i)FY / \text{Total Man-Years}(i)FY}{\text{Work Unit}(i)FY85 / \text{Total Man-Years}(i)FY85}$$

Work Unit(i)FY = Total number of a particular work unit, (i), completed within the fiscal year being measured.

Work Unit(i)FY85 = Total number of a particular work unit, (i), completed within fiscal year 1985, the baseline year.

Total Man-Year(i)FY = Total labor used, measured in man-years used to complete a particular work unit, (i), within the fiscal year being measured.

Total Man-Years(i)FY85 = Total labor used, measured in man-years used to complete a particular work unit, (i), within fiscal year 1985, the baseline year.

By calculating the ILPI for each of the 4th order work units, management can evaluate the efficiency of the labor used in each of the steps that lead to an approved Airborne Weapons Maintenance Plan. If a problem area is identified, the 3rd order work units can then be used to find the specific cause. This information can be used to direct improvement efforts to the areas that will produce the highest overall effect.

For example, suppose the review process for a guidance and control section type of Maintenance Plan seems to be less efficient than the average? The IPLI of the 4th order work unit would be lower than the average for the other types of Maintenance Plans. By then examining the 3rd order work units under this particular 4th order work unit, specific branches causing the delay in review can be identified. Then efforts to improve productivity can be applied (e.g. training, capital investment, etc.).

B. PRODUCTIVITY AND QUALITY IMPROVEMENT

In this section the productivity and quality enhancements suggested in the interviews will be evaluated.

1. More Specific Explanation of the Source Data Used to Derive the Technical Factors

Bases for deriving Technical Factors are described in Data Item Description, UDI-L-21592 [Ref. 12]. Normally, the number of inductions for one year would be used as a basis. This means that the cause of failure for each Maintenance Plan Subject (Missile (AUR)), Each Major Section, Container, etc.) would be recorded at the repair facility. This data over a one year period would then be used to calculate the technical factors. An alternative basis, if used, must be justified using the Maintenance Plan Rationale section of Part I.

Fleet Analysis Center (FLTAC) is responsible for collecting the data needed for computing the technical factors from the Weapon Stations, and then maintaining this data base. The system used is called the Maintenance Data Collection System (MDCS). MDCS is used by the Weapons Support Directorate, NAVAIRSYSCOM and others. Historically, there have been problems with this data base. The reliability of the data is in question. Often users of MDCS have found it necessary to obtain the original data from the Weapons Stations.

There are also problems with computer hardware and software interfaces between FLTAC and the MDCS users. A more thorough discussion of this topic is contained in a Naval Postgraduate School Master's Thesis by Richard B. Hancock [Ref. 21]. In his thesis, he recommends that a new Management Information System be designed and maintained by the users of this data [Ref. 21:pp. 18-19]. This researcher agrees with him. The new system should be designed from the ground up. Data should be obtained from the work bench of the repair facility at the time of maintenance. This system should also be designed to integrate with the Computer Aided Logistics System (CALs)*. This is an area that is recommended for further research.

2. Modify MPASS

Modify MPASS in two ways:

- a. Automatically calculate the Technical Factors.

Currently, a Maintenance Plan Preparer must first select the data to be used, then calculate the technical factors, and finally, enter the technical factors into MPASS. If the data to be used could be entered directly it would save in both data entry labor and in data

*CALs is a DOD wide logistics support system in development at NAVAIRSYSCOM.

entry errors (less data entered implies less chance of mistake).

b. Automatic Error Checking.

This would prevent some types of data entry errors prior to their occurrence. It would also save time for reviewers since they will only need to check to see if the initial entry is correct, the system will make sure that all dependent entries are then correct.

3. Advance Planning

Advance notice of Airborne Weapons Maintenance Plans to be reviewed in the near future would allow the Weapons Support Directorate to better plan their entire workload, thereby, enhancing productivity. This would be especially helpful at the change in the end of the fiscal year. MPASS has a newly added feature that will automatically identify maintenance plans associated with a particular weapons system that have comments in their change control files. This should aid the APML at NAVAIRSYSCOM-418 in identifying plans that need revisions. However, this is not as easy to accomplish as it appears. Users of MPASS still need to familiarize themselves with this feature.

Currently, NAVAIRSYSCOM-418 periodically reviews the Airborne Weapons change control file in MPASS for each maintenance subject, ideally, every other year [Ref. 19] to determine if the Maintenance Plan will need to be revised.

Additionally, if the Maintenance Plan is in need of revision, it may be assigned to another facility. Though NAVAIRSYSCOM-418 does attempt to maintain an even workload at each of their support facilities, it cannot predict ahead of time which specific Maintenance Plans in need of revision will be assigned to the Weapons Support Directorate [Ref. 15].

V. SUMMARY AND CONCLUSION

A. SUMMARY

This thesis began with a discussion for the need to enhance productivity within the government. In order to quantify productivity improvement, a way of measuring productivity is needed. Research was directed at the services performed by the Weapons Support Directorate, PACMISTESTCEN. The key to any form of productivity measurement is an understanding of the organization as whole entity. This also includes the environment in which it operates.

This resulted in development of a working definition for productivity and its importance in the management process. General guidelines for productivity enhancement and improvement were reviewed (e.g. employee involvement). Because a detailed study of the service to be measured is important, a thorough review of Airborne Weapons Maintenance Plan revisions was completed. This included the uses for the Maintenance Plans and the process used to revise the Maintenance Plans.

Information gathered was for use in the application of the Mundel method to develop a Internal Labor Productivity Index. The Mundel approach was applied to the specific

service of revising Airborne Weapon Maintenance Plans. Finally, the productivity enhancement suggestions obtained in the course of this study from the employees were evaluated.

B. CONCLUSION

1. Productivity Measurement in General

Productivity measurement is a complex process. Many factors can influence the usefulness of the index obtained. The specific approach used must depend upon the needs of the organization and the service involved. This allows productivity measurement to be designed into the existing management framework. It then can be a compliment to the organization's management philosophy.

Productivity measures must incentivize productivity. This is difficult to do without first having a thorough knowledge of what the service is used for and how it is accomplished. The work units used must to be directly related in some way to the particular goals of the organization.

The employees are the ones who must work within the proposed productivity measurement system. Early involvement is required to gain their support for the program. They are a valuable resource in determining what should be measured and how it should be measured, they can

not be ignored. Their insightful suggestions will yield productivity improvement.

2. Productivity Measurement at the Weapons Support Directorate

This thesis presents an approach to measure the productivity of the services performed by the Weapons Support Directorate, PACMISTESTCEN. Specifically, a productivity index for revising Airborne Weapon Maintenance Plans has been developed.

It can be used to evaluate performance and identify areas to target for productivity improvement. The combination of using both Internal Labor Productivity Indices for the 4th and 3rd order work units allows this. The 4th order is a good indicator of overall, general performance and to identify problem areas. The 3rd order can identify specific areas where the improvement can be made.

The approach developed by Mundel is a appropriate for productivity measurement of the Weapons Support Directorate. It builds a framework that is adaptable to many types of services. It provides a procedure to break down the services in such a way that they can be directly related to the resources used to produce them. This means that the work performed can then be measured and compared with past performance.

This productivity index can also be used to comply with the requirements of OMB Bulletin 87-12 [Ref. 3]. The OMB states that the productivity improvements should be measurable in terms of cost or time save (or avoided). The index is directly related to hours of labor used. The cost of labor saved is obtained by multiplying the standard rate by the hours saved through productivity improvement.

APPENDIX

THE MAJOR STEPS TO THE MUNDEL APPROACH* DEFINITIONS

Step 1 - Performing a General Reconnaissance

A general reconnaissance is a quick examination of the nature of the work, the organization, and personnel of the organization being studied, made to orient the analyst with respect to the general nature of the manpower management problem.

Step 2 - Developing a Work-Unit Structure

The delineation of the outputs of an organization, and the subparts of these outputs, in work-unit terms, resulting from an analysis of the work of an organization. The major criteria of a convenient work-unit structure are:

- a. Provides clear visibility of the relationship between objectives and the use of resources.
- b. Provides a level of work-unit suitable for forecasting the amount of outputs needed during future periods.
- c. Provides a level of work-unit suitable for applying some type of work measurement.

*This appendix is an excerpt of chapter six of Marvin E. Mundel's book Measuring and Enhancing the Productivity of Service and Government Organizations. [Ref. 6:pp. 59-90]

It is to be noted that the analysis proceeds from the objective, through the gross aggregation of outputs, downward. Experience indicates that only in this manner can a definitive description of end-product oriented outputs be obtained.

Step 3 - Selecting Work Measurement Methods

Work measurement is the term used for any and all techniques for determining numerical factors for converting a quantity of outputs (work-units) to a quantity of manpower resources needed to do the work. From the many techniques available, specific techniques must be chosen for use.

Step 4 - Making a Rough, Tentative Design of the Manpower Budget and Workload Forecasting System

The rough simulation to determine whether the work-units of the work-unit structure, if the work measurement was completed, could be used to develop a manpower budget. This step also includes a review of the feasibility of obtaining workload forecasts at some level of work-unit in the work-unit structure.

Step 5 - Making a Rough Tentative Design of the On-Going Manpower and Workload Management System

This step concerns the rough tentative design of the on-going control system which will eventually form, when completed and implemented, the basis of:

- a. A comparison of manpower budgeted and manpower used.
 - b. A comparison of workload forecasts and actual workloads.
 - c. An evaluation of the effectiveness with which manpower was used.
 - d. An evaluation of work force productivity.
 - e. An evaluation of unit costs.
 - f. An examination of the need for and the consequences of, decisions made when manpower and workload do not match during a program year.
- Hence, the system may be thought of as a basis for a continuous control system.

Step 6 - Familiarizing All Who Will Be Affected by the Changes With The New Approach

This step concerns the general dissemination of information concerning the program among the members of an organization, prior to any work measurement effort.

Step 7 - Applying the Selected Work Measurement Techniques

The actual gathering of data for the development of numerical factors for converting units of work to amounts of manpower required to do such work.

Step 8 - Reducing the Work Measurement Data To Work Measurement Standards

The reduction of the raw data collected in Step 7 to a form usable for:

- a. Manpower budget support.
- b. Manpower forecasting for the Budget Year and periods beyond the Budget Year.
- c. On-going manpower control.
- d. Internal Labor Productivity Index computation.

Step 9 - The Final Designing and Pre-Testing of the Manpower Budget and Workload Forecasting System

The design of a system (forms and procedures together with supporting data and documentation) to produce a work-unit, workload-based estimate of manpower needed for a Budget Year. Further, the extension of the approach to making manpower forecasts for 2 to 4 years beyond the Budget Year.

Step 10 - The Final Designing and Pre-Testing of the On-Going Manpower and Workload Management System

The design of a system (forms and procedures, together with supporting data) for comparing current workload and manpower data with budget forecasts.

Step 11 - Implementing the Manpower Budget And Workload Forecasting System

The implementation of the system designed in Step 9.

Step 12 - Implementing the On-Going Manpower and Workload Management System

The implementation of the system designed in Step 12.

Step 13 - Providing Follow-Up Assistance

Additional assistance, subsequent to implementation.

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